Military Global Positioning System (GPS) Augmentation System (MGAS)

Mr. Paul A. Regeon
ONR Code 32SO
Office of Naval Research
800 N. Quincy Street, BCT 1, Room 1211
Arlington, VA 22217-5660
phone: 703-588-0702 fax: 703-696-8406 e-mail: regeonp@onr.navy.mil

LONG-TERM GOAL

The Military GPS Augmentation System (MGAS) will demonstrate, through the use of a geo-synchronous, high power L-band transponder and leveraging existing architectures, a sensor-to-weapon data link which will permit targeting data updates, multiple secure message channels, and reduce the possibility of target area GPS jamming by providing a greater signal power in theater.

OBJECTIVES

The primary objective of the MGAS program is to develop a high power L-band transponder, a re-locatable ground system, software applications for re-targeting weapons in flight, launch into a geosynchronous orbit and demonstrate:

1) **Improved Accuracy** - Increases in GPS Location Accuracy for Platforms, Sensors and Munitions

2) **Improved Anti-Jamming** - Timing and Navigation

3) **Increased Navigation Messaging In Near Real Time (2 Second Latency)** - Multiple Potential Applications; Sensor-To-Weapon Messaging Protocols; Integrity Messages and Alternative Differential Protocols

4) **Space-Based Transponder to Demonstrate Next Generation Modulation Techniques, Navigation Messages and Higher Power Signals –** Supports Risk Reduction Activities for GPS III, GEO/MEO Mix Issues

This program will provide an Initial Operational Capability (IOC) of a Digital Fires Network (DFN) by fiscal year 2006.

APPROACH

The Office of Naval Research (ONR), Naval Space S&T Program Office, designed the Advanced Military Operational Support Satellite System (AMOSS) to transition multiple S&T experiments to demonstrate enhanced warfighting capabilities in the Indian Ocean. MGAS is one of 3 payloads to be launched as a result of multi-agency partnerships. ONR, as the Program Manager for N6, developed the Navy, NASA, NOAA partnership for the development of the Indian Ocean METOC Imager-Geostationary Imaging Fourier Transform Spectrometer (IOMI-GIFTS) program. The Ionospheric

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14. ABSTRACT
The Military GPS Augmentation System (MGAS) will demonstrate, through the use of a geo-synchronous, high power L-band transponder and leveraging existing architectures, a sensor-to-weapon data link which will permit targeting data updates, multiple secure message channels, and reduce the possibility of target area GPS jamming by providing a greater signal power in theater.

15. SUBJECT TERMS

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Mapping and Geocoronal Experiment (IMAGE) is sponsored by ONR and under development at the Naval Research Laboratory. The MGAS program was entered into the FY03 Advanced Concept Technology Program (ACTD) process in December, 2001. The 3 payloads were individually entered into the DoD Space Experiments Review Board (SERB) Process to compete for access to space. As a result of high rankings based upon military utility, the ONR executed a Memorandum of Agreement in July, 2002, with the DoD Space Test Program for launch on the MLV-05 mission, scheduled for March, 2006. The spacecraft development is shared between the interagency sponsors of the 3 payloads. The mission is designed utilizing two phases. Phase I is utilized to validate the technologies and science measurement concept to meet the NASA/NOAA requirements of the GIFTS experiment, for one year over CONUS. During this phase, the DoD payloads, MGAS, IMAGE and IOMI, will perform demonstrations and calibration/validation activities. Upon completion of Phase I, the satellite will be re-located to the Indian Ocean to begin Phase II, the DoD AMOSS mission, IOMI, IMAGE and MGAS.

The MGAS payload will be used to develop a Digital Fires Network (DFN) to provide a data link directly into GPS guided weapons through the existing weapon's GPS receiver. The DFN application leverages the existing communications connectivity between the targeting sensors and the Command and Control (C2) systems. Since DFN is an Open System Interconnection (OSI) based architecture, it can be integrated with multiple C2 architectures allowing Joint Service access to the MGAS payload data through a shared Ground Uplink Station (GUS). Target coordinates obtained from sources such as the Army's Grenadier BRAT targeting device through the Tactical Exploitation System and the Advanced Field Artillery Tactical Data System, the Marine Corps' Target Location and Designation Hand-off System (TLDHS) the Naval Surface Fires Control (NSFC) system, or from the Air Force's the CAOC's Time Critical Targeting cell can be routed to the Ground Up-link Segment (GUS) for transmission to the MGAS satellite transponder. The MGAS signal carrying the updated target location is relayed in near real-time to an in-flight GPS-guided munitions.

This capability, with a re-locatable ground system, provides forward-deployed forces, i.e. Special Forces Operational Detachment Team Alphas, Seal Teams and Long Range Reconnaissance Detachment teams, the ability to request precision responsive fire support without disclosing locations while operating Over the Horizon or beyond line of sight communication range. Additionally, these forward deployed combatants can focus the collection activities of other Intelligence Surveillance and Reconnaissance assets while maintaining a low probability of detection posture during the conduct of their missions. The capabilities that MGAS provides permits operational commanders an improved capability to geo-locate, track and engage high priority targets and targets of opportunity; develop a mechanism to plan, synchronize, and integrate collection from multiple disciplines in order to counter denial and deception efforts; use existing systems for optimizing and expanding the use of limited resources; and the ability to more rapidly and more accurately transmit data on targets of interest to tactical unit weapons systems while maintaining a degree of control during the munitions terminal phase.

MGAS utilizes several programs and leverages the concepts of:

- Navy's
  - Direct Sensor-to-Weapon Network (DSTWN) Demonstration Program
  - GI-Eye Precision Video Targeting Demonstration Program

- Naval Fires Network (NFN) and Naval Surface Fires Control System (NSFCS)

- Marine Corps Target Location and Designation Hand-off System
- Army/Marine Corps Advanced Field Artillery Tactical Data System (AFATDS)
- Army's
  - Grenadier BRAT (GB) Blue Force Tracking Device
  - Tactical Exploitation System (TES)
- Air Force
  - P/M-code MGAS Ground Station Upgrade Program
  - Joint Program Office G-Wired JDAM Upgrade Program
- Existing National Assets & Data Dissemination Architectures

A primary focus of the Military Utility Assessment will be to recommend a course of action for follow-on development and deployment after the ACTD has been successfully completed.

Precise Targeting Data	Provide real-time target geo-registration data for (a) re-locatable and (b) stationary targets relative to the precise positioning from the target sensor
Addressable Messaging	Send addressable messages in real-time to discrete GPS receivers
Jam Resistance	Demonstrate, during the Military Utility Assessment Phase, GPS anti-jam improvements using the high-power MGAS signal
Attacking Targets	Provide near real-time, in-flight, geolocation targeting data on stationary and relocatable targets ensuring the target is in the effects radius of the munition

Figure 1: Goals and Approach of the MGAS Program

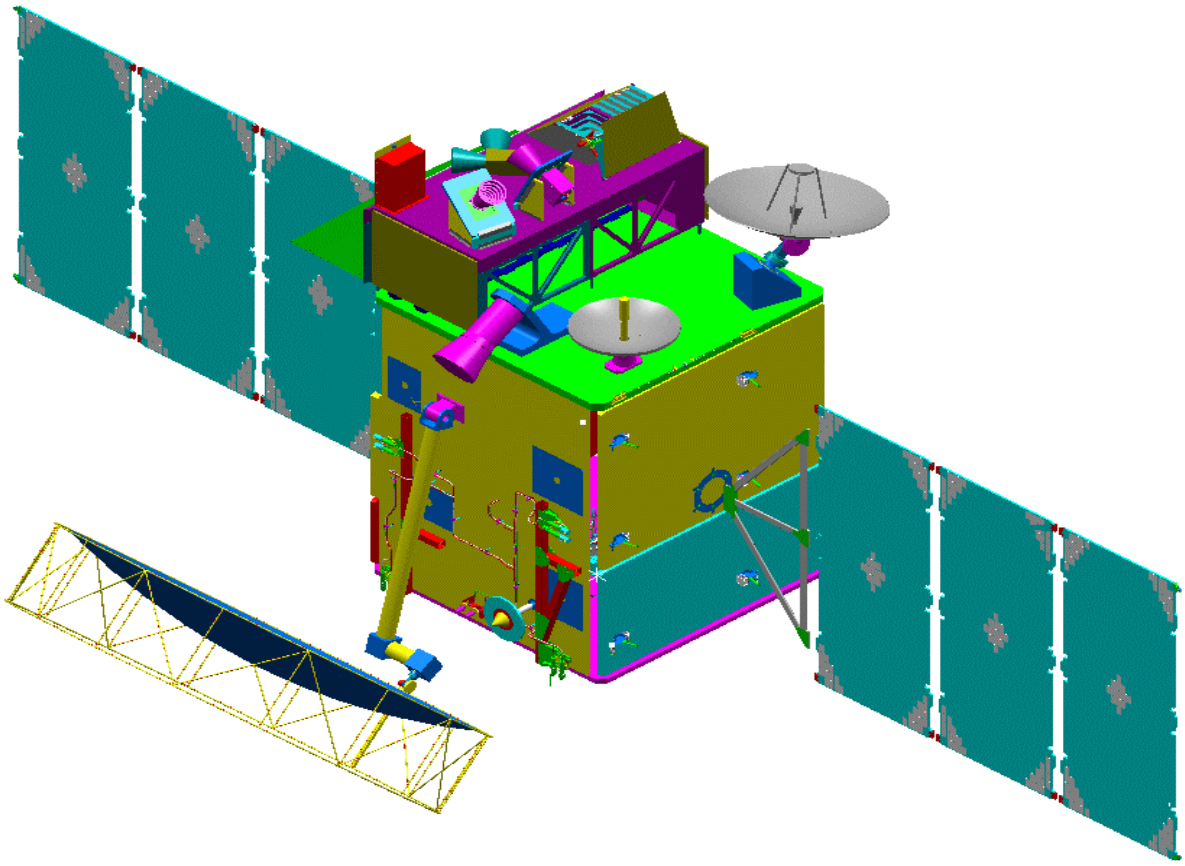

Figure 2. AMOSS Satellite Deployed With MGAS Spot Beam Antenna

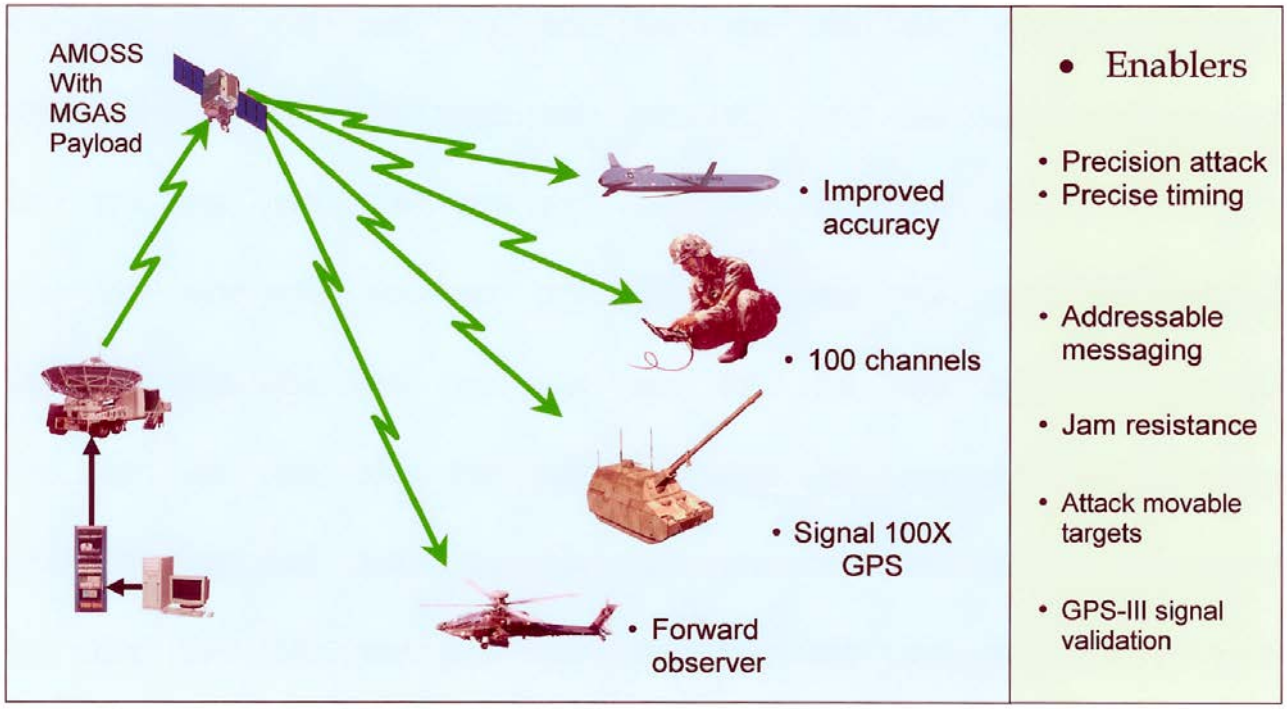

Figure 3. MGAS Military Capabilities

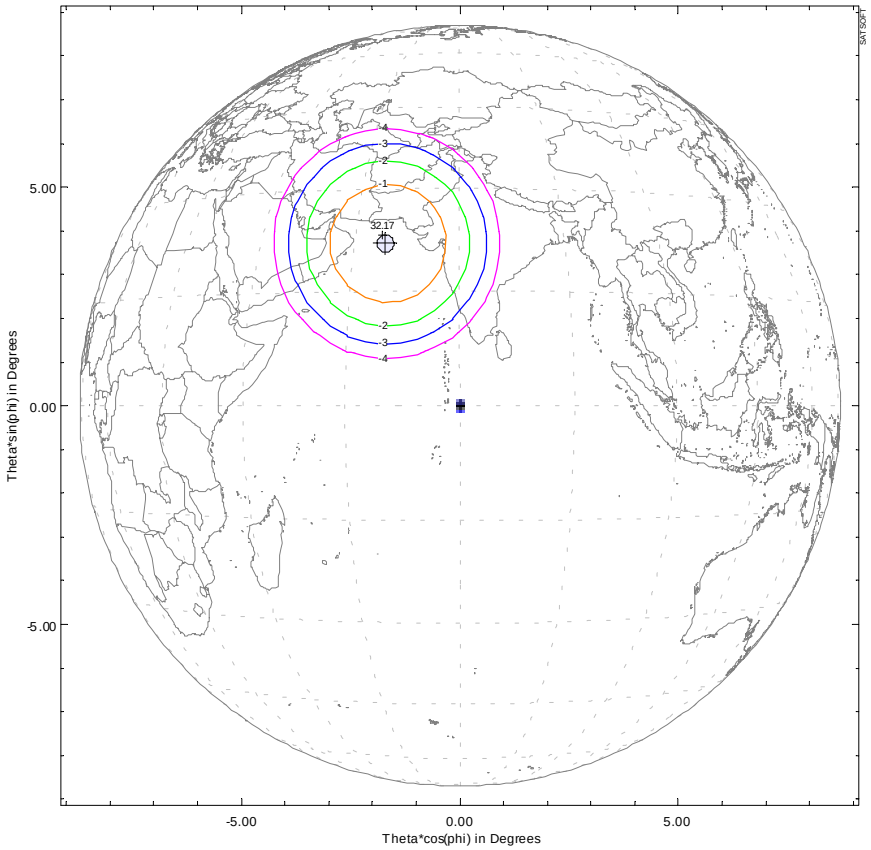

Figure 4. AMOSS Satellite at 75º East With MGAS Spot Beam

WORK COMPLETED

The MGAS ACTD program has successfully completed the FY03 ACTD process. The Office of the Secretary of Defense is in the process of identifying the funding required to execute the program. MGAS has been manifested with the DoD Space Test Program for launch on the MLV-05 Mission through an interagency Memorandum of Agreement between the ONR and STP.

RESULTS

The MGAS concept serves as both a complement to existing programs and provides a significant enhancement to existing GPS technology. The enhancements result in cost reductions as well as improvements in meeting warfighter requirements.

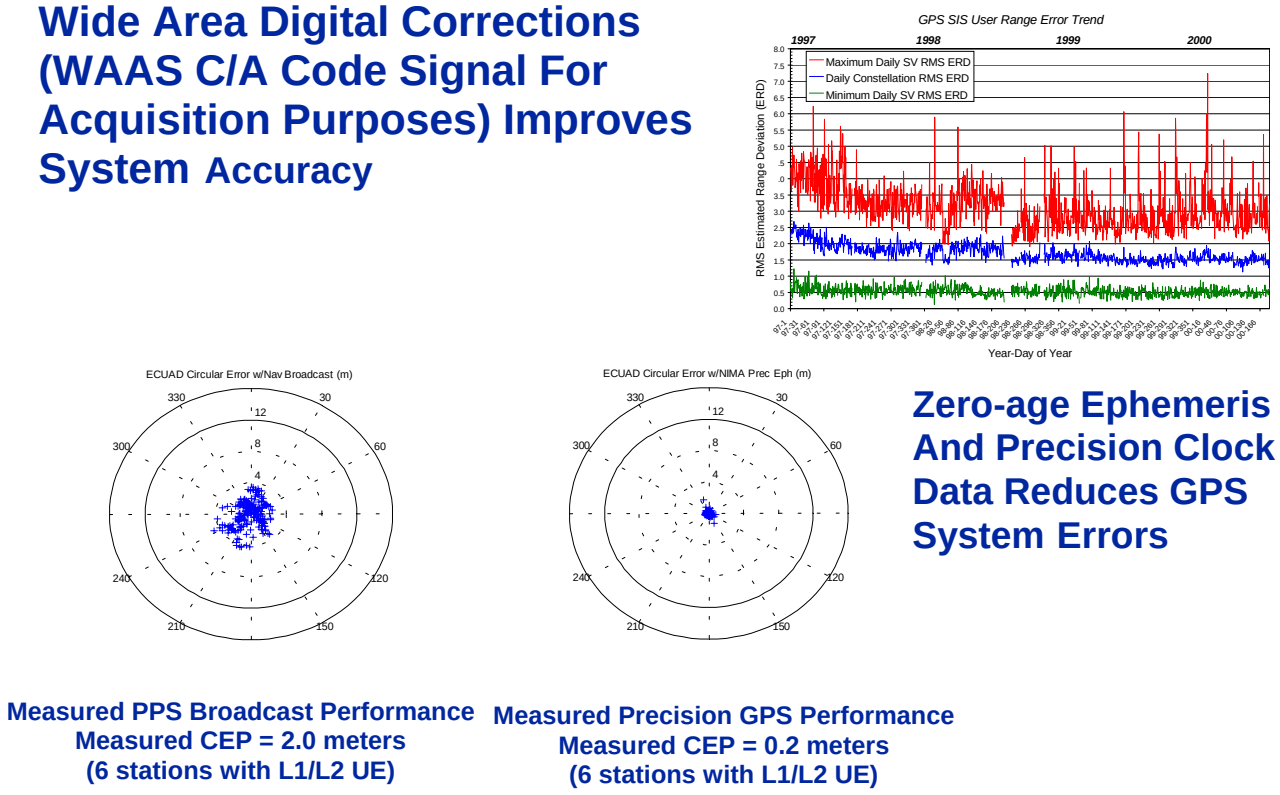

Figure 5. Increased GPS Accuracy

IMPACT/APPLICATION

The MGAS ACTD implements a capability to provide all-weather precise target coordinate updates to an in-flight GPS guided munition, providing U.S. forces the ability to redirect a guided munition after launch/firing. Through the use of a new geosynchronous satellite transponder, and leveraging existing architectures, a sensor-to-weapon data link will be realized to permit targeting data updates, multiple secure message channels, and reduce potential target area GPS jamming by providing greater signal power in theater through the use of the MGAS spot beam.

Existing GPS Wartime Values	Proposed Low-Risk MGAS Technology	Next Generation (2nd GPS Revolution)
• GPS-aided weapons are highly effective o GPS navigation already on most platforms o Inexpensive guidance o All-weather operation o Fits small, low-cost munitions • Time transfers used for communications (e.g., SINGARS) • Limitations o Need higher precision o Cannot attack moveable or moving targets o Need systemic anti-jam o Need GPS integrity data	• Civil GPS augmentation system is already built o MGAS uses same principles o Military extends use to include precision GPS and target updating messaging • Navy and Air Force research has extended civil techniques to P(Y) and new M codes o Prototype hardware already tested o Simulated direct sensor to weapons network demonstrated • Satellite transponder is commercial equipment	• Precision GPS is 100 times cheaper than custom seekers on weapons o JDAM - $500M planned seeker addition avoidable o Small munitions can do job of larger ones • MGAS initiates systemic anti-jam capability • New secure message channels to weapons without the need for additional receivers • Improved accuracy and integrity for all military GPS UE

The Military GPS Augmentation System ACTD demonstration will provide precise targeting for engagement of time critical stationary and re-locatable targets leveraging the Direct Sensor to Weapons Network (DSTWN) concept. The MGAS concept allows target coordinates to be routed to GPS-guided standoff weapons in flight through a military GPS augmentation system (MGAS).

Under the proposed ACTD, the joint service DFN connectivity will be demonstrated through the MGAS transponder. This will include supporting Army call-for-fire using the Grenadier BRAT targeting sensor developed by Army Space Program Office and Marine Corps' TLDHS call-for-fire through the shipboard Naval Surface Fire Control System.

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While the Grenadier BRAT (GB) system is proven technology for Blue Force tracking, the MGAS will demonstrate a new added capability to apply time critical applications such as, ISR asset cross-cueing, Over-the Horizon targeting coupled with in-flight retargeting to forward deployed forces. During the initial test, the concept will perform testing to identify what minimum latency can be achieved for routing high priority targeting messages through the GB architecture. Blue Force tracking coordinates will be sent to the Tactical Exploitation System (TES) via the TDDS architecture. When a high priority target or Time Critical Target emerges, the GB equipped combatant switches the GB transponder from Blue Force Tracking to a targeting mode. The forward observer determines the target's coordinates with the integrated laser range finder, the target coordinates and target type are

sent over the existing GB communication architecture which are subsequently broadcast over TDDS. The TDDS broadcast is received by both the Naval Fires Network and the Army's TES. The target nomination is reviewed, coordinated and assigned to an engagement platform. At the platform the GPS-guided munition is programmed with the target coordinates. From TES/NFN a message to the observer (MTO) is sent (i.e. One round JDAM; ETA 3 min) to the MGAS uplink station where the message is addressed to the GB terminal submitting the request for fire. Each GB has its own discrete address and that address is has been programmed into the JDAM munition so only an update from the requesting GB will be processed by the JDAM. Count down of the munition's arrival are provided to the forward observer, via the MGAS messaging feature, at five minute intervals the final message is a thirty seconds "Splash". If the target moves during the flight of the munition, the forward observer simply "points and clicks" the laser range finder to determine the new coordinates which are passed to the uplink station, and transmitted to the GPS receiver of the munition, resulting in munition trajectory correction. The MGAS ACTD will demonstrate transmitting in-flight targeting data to a GPS-guided weapon from a Marine Forward Observer with TLDHS or a Special Operations team equipped with Grenadier BRAT coupled with a laser range finder directly to a GPS-guided weapon.

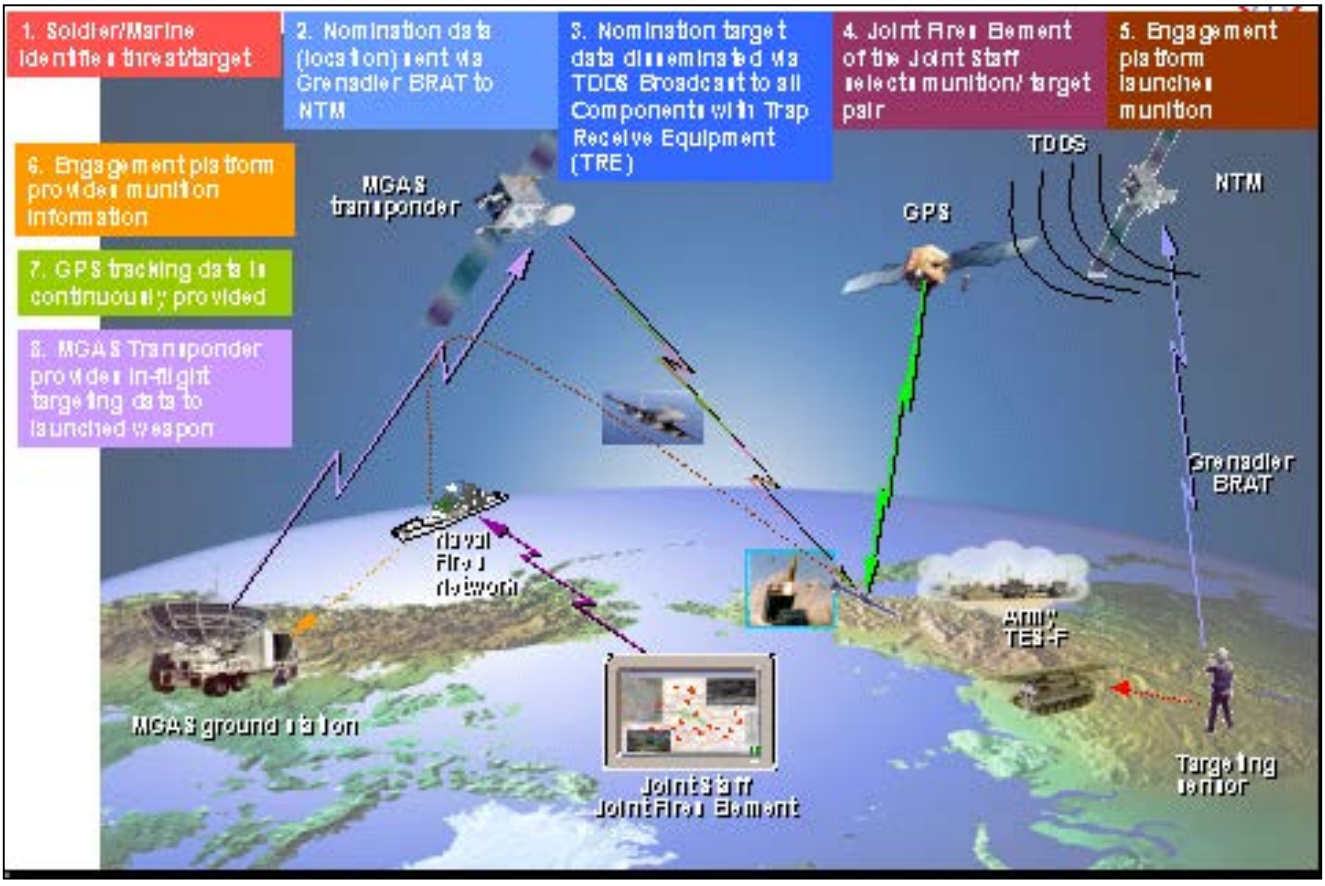

Figure 6. MGAS Concept of Operations

TRANSITIONS

It is envisioned that the Geo-Meo mix GPS resolution issues as well as the technical knowledge achieved to successfully avert jamming of GPS signals will be transitioned to the AF GPS III Program Office. Additionally, software upgrades to weapons re-targeting will be transitioned to the service developing the munition. The capabilities of the MGAS payload will be transitioned to a CINC upon successful demonstration of the ACTD.

RELATED PROJECTS

1) The IOMI-GIFTS Program: Using advanced technologies, the Indian Ocean METOC Imager (IOMI) Program will develop and launch a geostationary imager to demonstrate over the Indian Ocean the military operational utility of an advanced weather sensor. MGAS shares the spacecraft bus with the IOMI-GIFTS and IMAGE payloads on the AMOSS mission.

2) The Ionospheric Mapping and Geocoronal Experiment: The IMAGE space weather experiment, sponsored by the Office of Naval Research and being developed by the Naval Research Laboratory, (NRL-506) monitors the earth's ionosphere from a geo-synchronous orbit. The objective is to track regions of ionospheric irregularities such as Spread-F and scintillation (which cause fading and dropouts of frequencies up to and including GPS); and to determine total electron content, maximum ionospheric height (Hmax), and ionospheric tilts (which determine radio propagation). IMAGE share the spacecraft bus with the IOMI-GIFTS and MGAS payloads on the AMOSS mission.

3) The Army Grenadier BRAT/Laser Range Finder Program: The basic CONOPS for MGAS utilizes a forward observer (Army Operational Detachment Alpha, Navy SEAL Team or Special Operations Forces) equipped with a Grenadier BRAT/Laser Range Finder (GB/LRF) or other appropriate device to identify a target. GB/LRF will send target data such as target type, time, and target location for broadcast via the TRAP Data Dissemination System to command and control nodes where targeting decisions occur. The targeting cell will direct the appropriate component to launch a weapon. Prior to launch, the weapon receives its normal programming plus a unique GPS Navigation ID that allows the weapon to accept target coordinate updates from MGAS. If after the weapons launch, the target changes location, the forward observer will reacquire the target with the GB/LRF and pass the new coordinate(s) to an MGAS uplink site, which relays the new coordinates, via the MGAS ground station/payload, to the weapon so it can change its trajectory to the updated target location. It is envisioned that MGAS will have enough individual Navigation IDs to be able to simultaneously control approximately 100 in flight weapons.

4) DoD Space Test Program: The DoD Space Test Program is chartered to provide routine access to space for organizations who do not have access to “routine access to space”. The MLV-05 Program Office of the DoD Space Test Program is providing the access to space for the IOMI-GIFTS, IMAGE and MGAS payloads utilizing a Delta IV class launch vehicle. The MLV-05 program consists of approximately 10-11 additional payloads from the DoD Space Experiments Review Board ranking list. In August 2002, the STP contracted with Boeing to provide the launch vehicle integration for the mission.